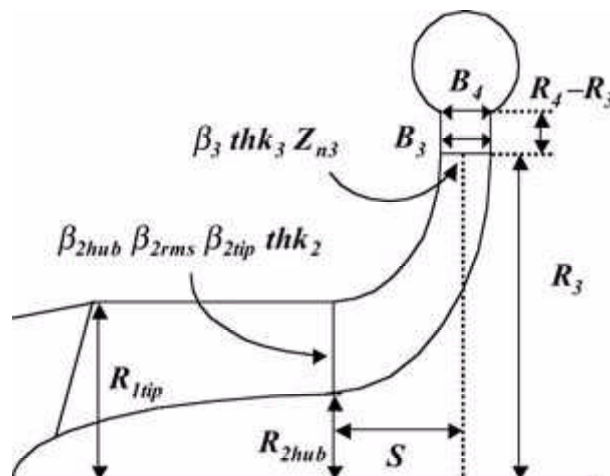


Turbopump Performance Improved by Evolutionary Algorithms

The development of design optimization technology for turbomachinery has been initiated using the multiobjective evolutionary algorithm under NASA's Intelligent Synthesis Environment and Revolutionary Aeropropulsion Concepts programs.

As an alternative to the traditional gradient-based methods, evolutionary algorithms (EA's) are emergent design-optimization algorithms modeled after the mechanisms found in natural evolution. EA's search from multiple points, instead of moving from a single point. In addition, they require no derivatives or gradients of the objective function, leading to robustness and simplicity in coupling any evaluation codes. Parallel efficiency also becomes very high by using a simple master-slave concept for function evaluations, since such evaluations often consume the most CPU time, such as computational fluid dynamics. Application of EA's to multiobjective design problems is also straightforward because EA's maintain a population of design candidates in parallel. Because of these advantages, EA's are a unique and attractive approach to real-world design optimization problems.

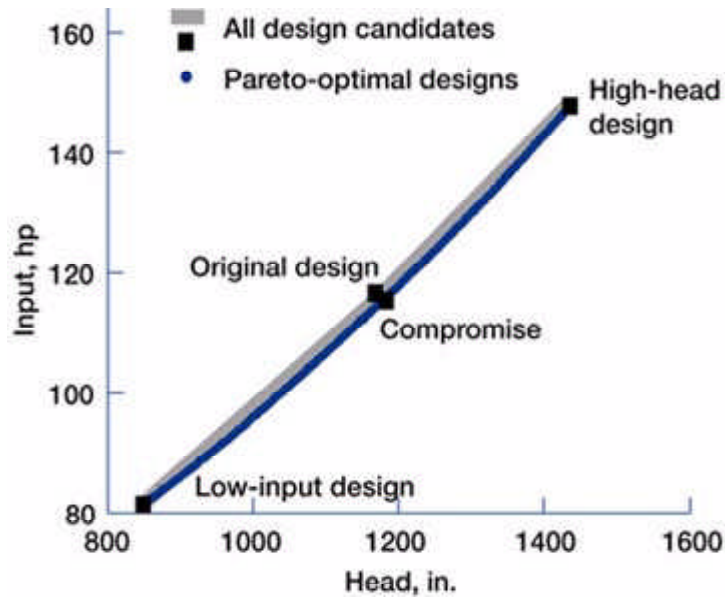


Design parameters for a multistage pump. β , relative angle from tangential; thk , normal blade thickness; R , radius; B , blade span. Objective function values of the multistage pump design.

Long description: Diagram shows locations of R_{1tip} , R_{2hub} , R_3 , $R_4 - R_3$, S , B_3 , B_4 , β_{2hub} , β_{2rms} , β_{2tip} , thk_2 , and β_3 , thk_3 , Z_{n3} .

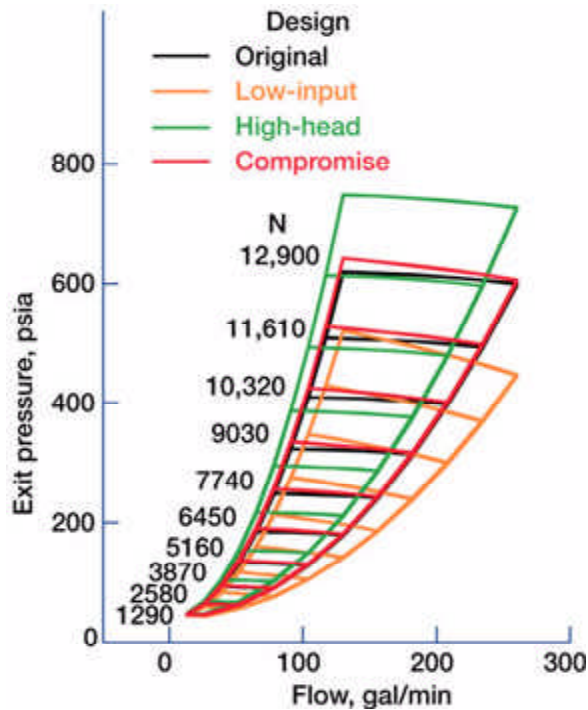
To demonstrate the feasibility of the present approach, the redesign of the RL10A-3-3A liquid oxygen pump, shown in the preceding sketch, was investigated at the NASA Glenn Research Center. The next graph displays the Pareto-optimal solutions maximizing pressure head and minimizing input power; these include some designs that outperform the original design in both parameters by more than 1 percent. Moreover, the optimal designs give superior performance over the off-design operations (see the final graph). Detailed

observation of the design results also can reveal some important design policies for the turbopump design of cryogenic rocket engines.



Objective function values of the multistage pump design.

Long description: Graph shows data for all design candidates and for Pareto-optimal candidates. Low-input, compromise, original, and high-head designs are shown.



Pump overall performance map.

Long description: Graph shows data for original, low-input, high-head, and compromise designs. Data are given for 1290, 2580, 3870, 5160, 6450, 7740, 9030, 10,320, 11,610,

and 12,900 N.

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